LARVAL DEVELOPMENT OF *Hoplias* cf. *lacerdae* (PISCES: ERYTHRINIDAE) AND DELAYED INITIAL FEEDING EFFECTS

Rodolfo N. Sirol [1*]; Eliane Menin [2]; Dálcio R. Andrade [3]; and Martinho A. Silva [1]

[1]Departamento de Zootecnia - Universidade Federal de Viçosa - 36571 000 - Viçosa - MG, Brasil, [2]Departamento de Biologia Animal - Universidade Federal de Viçosa - 36571 000 - Viçosa - MG, Brasil, [3]Universidade Estadual Norte Fluminense CCTA, Av.Alberto Lamego, 2000 - 28015620 - Campos dos Goitacazes - RJ, Brasil

ABSTRACT

Larval development of *Hoplias* cf. *lacerdae* was studied under laboratory conditions. After hatching, ontogenetic changes were recorded on food-deprived larvae in 12-hour intervals. Mouth opening occurred after 2.5 days and notochord terminated flexure in 6.5 days. Notochord length increased at a constant rate until complete yolk absorption (13,5 days). Larval dry weight and body height diminished gradually up to 21 days after hatching, when all starved larvae died. Every 12 hours after yolk absorption, groups of larvae (n=15), were separeted, and fed with *Artemia* nauplii for 10 days. The point-of-no-return (when 50% of larvae were unable to feed or to assimilate ingested food after delayed feeding), was not apparent in this species.

Key words: Fish larva, *Hoplias*, larval development, starvation, point-of-no-return.

INTRODUCTION

Hoplias cf. *lacerdae* is a representative of the family Erythrinidae, whish is spreadErythrinidae occuring from southern Central America to the Buenos Aires Province in Argentina (RINGUELET, 1975). It is a freshwater fish adapted to well-oxigenated streams (RANTIN, et al. 1992). This species lays demersal eggs annually, and parental care is displayed until larvae become free swimmers. During larval stage, *H.* cf. *lacerdae* is planctofagus and voracious, becoming carnivorous as adults. Besides the value as game fish, the genus *Hoplias* is potentially valuable for commercial breeding, specially as a control of prolific species in polyculture conditions. However, the biology of *Hoplias* cf. *lacerdae* is still poorly understood during the initial developmental stages.

Yolk depletion represents a milestone in the life of larvae, when endogenous food regime is supplemented with exogenous resources. Thus, maximum resistance to the delayed

[*] Corresponding author

first feeding is relevant for ecological behavior and commercial breeding. In this paper, the maximum allowable delay of initial feeding was determined and changes in morphology of food-deprived larvae were also recorded.

MATERIAL AND METHODS

Fertilized eggs of *Hoplias* cf. *lacerdae* were obtained from natural spawning in a broad tank near the laboratory. In the laboratory, eggs and larvae were reared under controlled conditions: dark regime, 26.5± 0.3^0C, and semi-static systems. Aquarium (15 l) were used to rear eggs and larvae. The aquarium was siphonated daily, when 90% of the water was exchanged and aerated at or near saturation levels, with air compressed through air stones. Next for larval development studies, 20 larvae were fixed in 5% formalin every 12 hours after hatching, until reached total mortality by starvation (survival was monitored twice a day). During the experiment; notochord length, height of body at anus, yolk length (*L*) and height (*H*) were measured; yolk volume (*V*) was calculated according to the formula $V=(\pi/6)LH^2$ (BLAXTER & HEMPEL, 1963). Data of individual dry weight were obtained after dessicating larvae in stove for 24 hours at 55^0C. Timing for mouth opening, flexion of notochord, and yolk absorption of 50%, as well as the time to 100% mortality of the larvae were recorded. The same events of their ontogenetic development were described throughout the starvation period, and data were tested by analyses of variance and regression analyses.

To determine the existence of the point-of-no-return (PNR), fined by the inability of 50% of larvae to feed actively (BLAXTER & HEMPEL, 1963), sets of 15 larvae were sampled from the starving group and placed in 1 l plastic tanks (in duplicate). These larvae were fed *ad libitum* every 12 hours with live *Artemia* nauplii for 10 days. Nauplii were previously rinsed in freshwater and offered to larvae. After this period, larvae were fixed in 10% formalin. Sampling went on until all starving fish died. Fed larvae were kept under similar conditions as starving ones, though temperature was not controlled and natural photoperiod was 12/ligth:12/dark (Table 1). Comparison of the regression coefficient for each trait (length, height, and weight) for the two conditions (before and after feeding) was made by student test ($\alpha < 0.05$).

RESULTS AND DISCUSSION

Water temperatures were recorded daily at 8.00 A.M. and 8.00 P.M. and ranged from 26.2 to 26.8^{0}C. In the morning, dissolved oxygen ranged from 7.85 to 8.02 mg/l and pH from 7.02 to 7.25. Water quality during each sampling did not differ significantly.

The embryonic phase of *H.* cf. *lacerdae* seemed shorter than expected for an embryo with large-yolked demersal eggs (48 h at 28^{0}C, RIBEIRO & GONTIJO, 1984), opposite to *Odontesthes humensis* (17 days at 17^{0}C, PHONLOR & VINAGRE, 1990), *Leuresthes tenuis* and *Menidia menidia* (both approximately 2 weeks, MIDDAUGH et al., 1983). Contrasting with these species, *H.* cf. *lacerdae* larvae were premature at hatching, their bodies and eyes were not pigmented, and mouth were not opened, standing still on the bottom of aquarium. Initial development of *H.* cf. *lacerdae* is summarized in Figure 1. Twelve hours after hatching notochord length was 7.01±0.17 mm (mean±SE), dry weight 2.05±0.12 mg, and yolk volume 4.15 µl. Two and a half days after hatching, with 7.9±0.2 mm notochord length and 1.89±0.14 mg dry weight, larvae showed pigmentation around head and eyes, the mouth was opened. The larvae stood still on the bottom throughout the period in which they were reared, probably indicating high efficiency of nutrients from yolk to body. This behavior may be explained by the fact that this species showed parental care until larvae were able to swim. Contrasting with this patterns, larvae of *O. humensis, L. tenuis, and M. menidia*, which showed no parental care, typically hatched with opened mouth, they are active swimmers, and their bodies and eyes were pigmented.

KENDALL et al. (1984) discussed that notochord flexion was a fundamental event during development, as the hypochordal development of the homocercal caudal fin. Notochord flexion of *H.* cf. *lacerdae* larvae started 4.5 days after hatching; two days later it was completed, this interval (4.5 to 6.5 days after hatching) corresponded to the “preflexion”, “flexion”, and “postflexion” stages described by KENDALL et al. (1984). At this moment, the larvae had 9.64±0.25 mm notochord length and 1.76±0.15 mg dry weight.

The notochord length followed the square root model, with maximum value equal to 9.50 mm (12.6 days after hatching) (Fig. 1). The height of body at anus also followed the same model of notochord length and the maximum value was equal to 0.85 mm (13.8 day after hatching) (Fig.1). This suggested that slimming may derive from a change of energy flow, making the onset of exclusive yolk source to a stage where other tissues suppled energy as well.

These results are consistent with those reported by THEILACKER (1978) for *Trachurus symmetricus* and PHONLOR and VINAGRE (1989) for *Odontesthes argentinensis*. The dry weight was fitted by a linear model, that described the lose of dry matter throughout the experiment (Fig. 1).

The rate of yolk absorption was similar to that described by HEMING and BUDDINGTON (1988). Immediately after hatching the rate of yolk absorption was high, decreasing constantly until yolk depletion. The rate of yolk absorption became slower near exhaustion, probably in response to both a decrease in absorption surface area as the yolk shrank, and the changing composition of yolk (Fig. 1). Yolk exhaustion occurred 13.5 days after hatching (9.64±0.2 mm notochord length and 1.10±0.11 mg dry weight), suggesting that the posthatch phase had great importance for initial development.

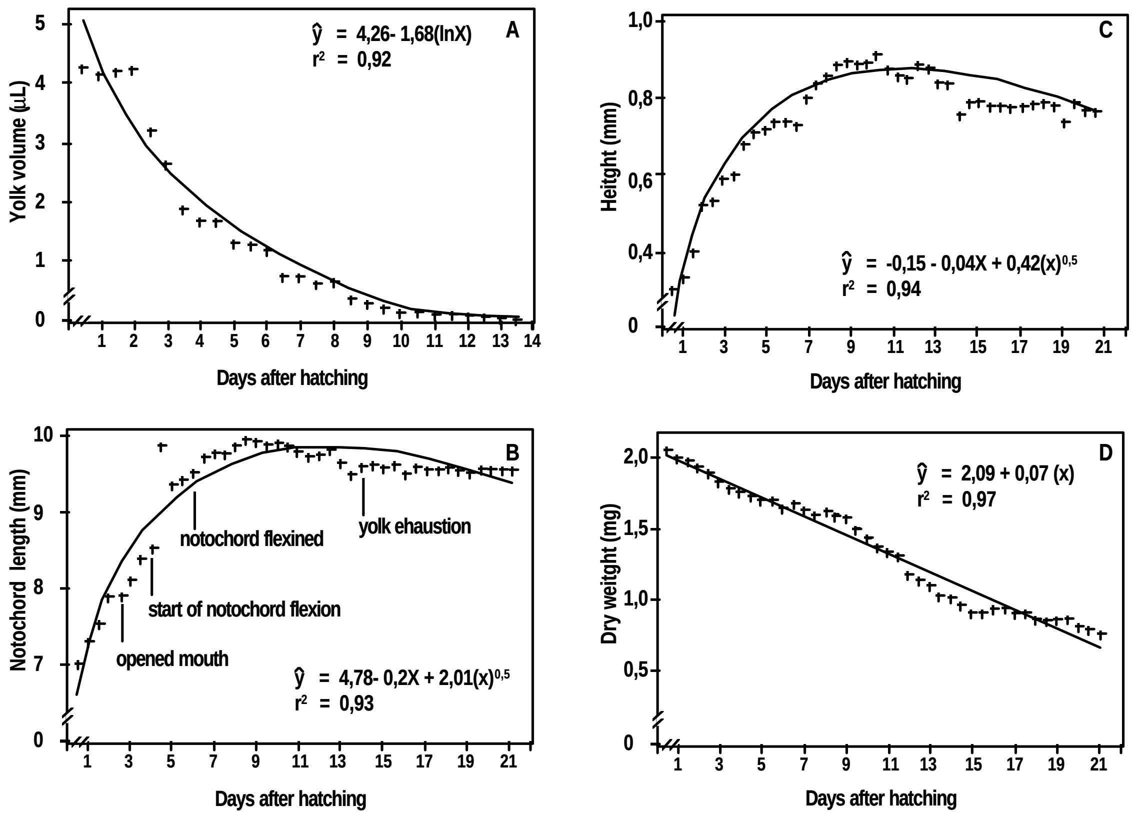

Fig.1. Yolk volume (A), notochord length (B), height at anus(C), and dry weight (D) regressions of *Hoplias* cf. *lacerdae* larvae under starvation.

Total mortality by starvation occurred 21 days after hatching (9.62±0.26 mm notochord length and 0.81±0.10 mg dry weight), though, survival until 19 days was 100%. The "critical period", described by FABRE-DOMERGUE and BIÉTRIX (1897) as a transitory period between exclusive endogenous food and exogenous food pursue might not occur in this fish. This is suggested due to the ability for capturing prey of food-deprived larvae until 6.5 days after yolk exhaustion (20 days after hatching) without influence in survival of *H.* cf. *lacerdae* larvae. Although, cannibalism was not observed until the end of the experiment, this behavior has been frequently observed in the laboratory. BLAXTER (1988) suggested that mortality by predation, could predominate over starvation on some occasions, and cannibalism seemed to be an important factor for recruitment of this species. This fact could be verified in juveniles and adults of *H.* cf. *lacerdae*.

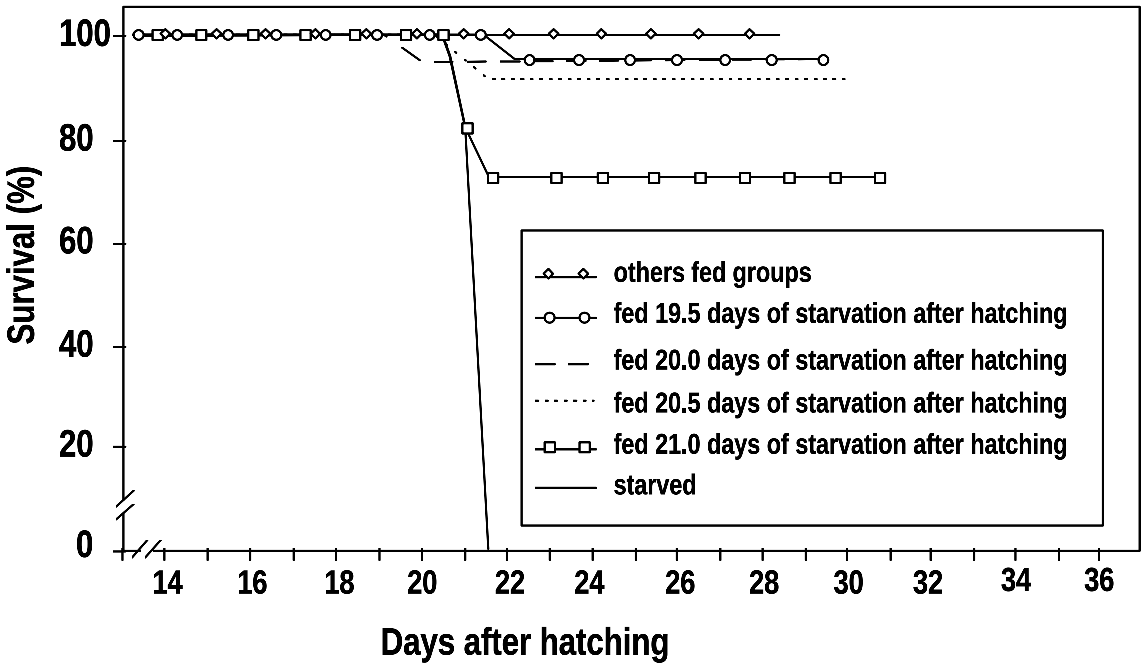

Fig. 2 The effect of delayed first feeding on the survival of *Hoplias* cf. *lacerdae* larvae

The progressive delayed initial feeding effects on larval growth after yolk exhaustion is presented in Figure 2. All groups of fed larvae showed excellent survival, (≥ 83.3%), consequently, it could be inferred that PNR was not found in *H.* cf. *lacerdae*. Likewise, PNR has not been detected in *Leuresthes tenuis* (MAY, 1971), *Morone saxatilis* (ROGERS and WESTIN, 1981), *Ammodytes personatus* (YAMASHITA & AOYAMA, 1986), and *Odontesthes argentinensis* (PHONLOR and VINAGRE, 1989). However, STRUSSMANN and TAKASHIMA (1992) suggested that factors such as kind of food, number of specimens, and laboratory conditions, may affect survival rates of starving larvae.

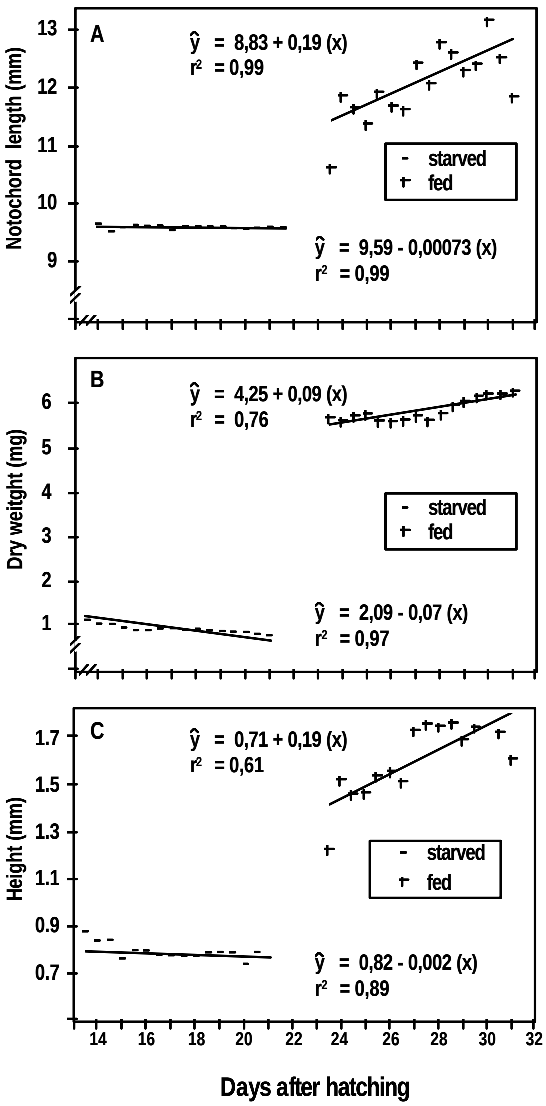

Fig. 3 Notochord length (A), height at anus (B), and dry weight (C), regressions before and after feeding period of *Hoplias* cf. *lacerdae* larvae.

Differences in regression coefficient were observed between groups after and before feeding time ($p<0.05\%$), and larvae after ten days of feeding showed advanced metamorphosis, growing approximately 500% relative to starving larvae. The regression coefficient after feeding period was positive and opposite to that obtained before feeding, suggesting that larvae showing highest growth after ten days of feeding were those with the longest delay of first feeding (Fig. 3). These phenomenon were interpreted as compensatory gain, explained by increase of larvae age and by the temperature that was higher for the older groups (Table 1). It is apparent from the table that the gain in dry weight after feeding period were higher in older groups of larvae. These data suggested that larvae has to be fed until 6.5 days after yolk exhaustion at 26.5^{0}C.

Table I - Physics and chemistry of water during feeding of *Hoplias* cf. *lacerdae* larvae.

DAY*	O_2D mg of O_2/l	SATURATION OF O_2D(%)	Ph	TEMPERATURE (^{0}C)	GAIN OF DRY WEIGHT (mg)**
14	7,95	102	6,94	22,1	
15	7,88	101	6,92	23,0	
16	7,65	102	6,89	25,0	
17	7,80	101	7,01	24,3	
18	7,86	100	7,00	23,5	
19	7,60	101	6,86	25,2	
20	7,65	102	6,84	25,1	
21	7,77	100	6,87	24,3	
22	7,85	102	6,92	23,8	
22.5					
23	7,92	103	6,87	23,6	
23.5					4.55
24	7,79	101	6,98	23,9	4.60
24.5					4.66
25	7,91	102	6,92	23,5	4.74
25.5					4.63
26	7,58	98	6,75	24,3	4.62
26.5					4.60
27	7,91	103	6,92	24,4	4.68
27.5					4.63
28	7,83	104	6,98	25,8	4.70
28.5					5.04
29	7,82	104	6,86	26,1	5.15
30.5					5.23
31	7,67	104	6,92	26,5	5.29

* The chemistry and physics data of water were not regestred at half days.
** Mean gain of dry weight of larvae after 10 days of feeding (n=15).

ACKNOWLEDGEMENTS

The authors thanks Derghan,J. and Sampaio,L.A. for their critical suggestions regarding the manuscript. This article was a part of the Magister Science Thesis of Sirol,R.N., supported by CNPq scholarship. Andrade,D.R. and Silva,M.A. were supported by a CNPq Fellowship.

REFERENCES

BLAXTER,J.H.S. Pattern and variety in development. In: HOAR,W.S. & RANDALL,D.L., ed. ***Fish physiology***. New York, Academic Press, 1988. v.11, pt.a, p.1-48

BLAXTER,J.H.S & HEMPEL,G. The influence of egg size on herring larvae (*Clupea harengus* L.). **J.Cons.Intern.Explor.Mer.**, v.28, n.2. p.211-240, 1963.

FABRE-DOMEGUE,P. & BIÉTRIX,E. La période critique post-larvaire des poissons marins. **Bul.Mus.Hist.Nat.**, v.3, p.57-58, 1897.

HEMING,T.A. & BUDDINGTON,R.K. Yolk absorption in embryonic and larval fishes. In: HOAR,W.S. & RANDALL,D.J., ed. ***Fish physiology***. New York, Academic Press, 1988. v.11, pt.a, p.408-438.

KENDALL,A.W; AHLSTROM JR,E.H.; MOSER,H.G. Early life history stages of fishes and their characters. In: MOSER,H.G. ed. ***Ontogeny and systematics of fishes*****.** Am.Soc.Ichthyol.Herpetol. Lawrence, Kansas, Allem Press, 1984. p.11-22.

MAY,R.C. Effects of delayed initial feeding on larvae of grunion, *Leuresthes tenuis* (Ayres). **Fish.Bul.,** v.69, n.2, p.411-425, 1971.

MIDDAUGH,D.P.; KOHL.H.W.; BURNETT,L.E. Concurrent measurement of intertidal environmental variables and embryo survival for the california grunion, *Leuresthes tenuis*, and atlantic silverside, *Menidia menidia* (Pisces:Atherinidae). **Calif. Fish and Game** v.69, n.2, p.89-96, 1983.

PHONLOR,G. & VINAGRE,L.E.C. Efeito do retarde da primeira alimentação sobre o crescimento e a sobrevivência da larva de *Odontesthes argentinensis* (Cuv. e Val., 1835). **ATLÂNTICA,** v.11, p.63-75, 1989.

PHONLOR,G. & VINAGRE,L.E.C. Fertilização artificial, incubação, crescimento e sobrevivência das larvas de *Odontesthes humensis* (De Buen, 1953) criadas em laboratório. **Rev.Bras.Biol.,** v.50, n.2, p.335-343, 1990

RANTIN,F.T. et. al. Respiratory responses in relation to mode of life two erythrinid species (*Hoplias malabaricus* and *Hoplias lacerdae*). **J.Fish.Biol.,** v.41, p.805-812, 1992.

RIBEIRO,D.M. & GONTIJO,V.P.M. Reprodução de trairão em cativeiro. **Inf. Agropec.,** v.110, p.20-25, 1984.

RINGUELET,R.A. Zoogeografia y ecologia de los peces de aguas continentales de Argentina y consideraciones sobre las areas ictiológicas de América de Sur. **Ecosur,** v.2, p.1-122, 1975.

ROGERS,B.A. & WESTIN,D.T. Laboratory studies on effects of temperature and delayed initial feeding on development of striped bass larvae. **Trans.Amer.Fish.Soc.,** v.110, p.100-110, 1981.

STRÜSSMANN,C.A. & TAKASHIMA,F. Larval growth and point-of-no-return in fish. **Océanis,** v.18, n.1, p.27-39, 1992.

THEILACKER,G.H. Effect of starvation on the histological and morphological characteristics of jack mackerel, *Trachurus symmetricus*, larvae. **U.S.Fish.Bul.,** v.76, n.2, p.403-414, 1978.

YAMASHITA,Y. & AOYAMA,T. Starvation resistence of the japanese sand eel *Ammodytes personatus*. **Bul. of the Jpn. Soc. of Sci. Fish.,** v.52, n.4, p.635-639, 1986.

Received: 30 January 1998;
Revised: 20 June 1998;
Accepted: 30 June 1998.